50X1-HUM

Page Denied

Next 2 Page(s) In Document Denied

INFORMATION, "Oceanology", Academy of Sciences of the U.S.S.R., 1961, No. 4, pages from 745 to 753

by P. L. Bezrukov

RESEARCH ON THE INDIAN OCEAN DURING THE 33rd VOYAGE OF THE RESEARCH VESSEL "VITYAZ"

The 33rd voyage of the research vessel "VITYAZ" of the Institute of Oceanology of the U.S.S.R., like its 31st voyage, took place in accordance with the program of international research on the Indian Ocean organized by the Special Committee on Oceanic Research of the International Council of the Scientific Union. Thirteen countries agreed to participate in carrying out this program, which was planned to continue for several years: U.S.S.R., Australia, England, India, U.S.A., France, Japan and several others. The actual decision to conduct systematic research on the Indian Ocean was dictated by the exceptionally incomplete knowledge of this ocean.

The Soviet Union initiated this program before most of the other countries by sending "VITYAZ", on its 31st voyage, into the Indian Ocean in October, 1959. This first cruise took place mostly in the northern part of the ocean and was completed in Odessa in April, 1960 (5). Simultaneously, during the winter 1959-1960, the Australian "DIAMANTINA", American "VEMA", and French "LA PERCUSE" carried out their oceanographic work in the southern part of the Indian Ocean.

In the beginning of October, 1960 "VITYAZ", on its 33rd voyage, was sent to the Indian Ocean once again. The program of this voyage consisted of complex oceanographic research on the northern part of the ocean, including the Arabian Sea, Bay of Bengal, and Andaman Sea, as well as the central part of the ocean (south to 40° Southern Latitude) and the region of the northwestern half of the Java Trench.

The basic aims of the expedition were to collect material and conduct observations relating to the following scientific problems:

1. Water circulation and deep currents;
2. Definitions of oceanic frontal zones;
3. Thermal balance and interchange of oceanic waters;
4. Physics of the near-surface atmospheric layer over the ocean;
5. Bottom relief and tectonics;
6. Bottom sediments and suspended matter in connection with sediment-genesis problems; geologic history of the ocean;
7. Definition and dynamics of chemical processes in the ocean;
8. Fish distribution, plankton and benthos, in order to define the productive regions of the ocean;
9. Interconnection and geographic zoning of physical, chemical, and biologic characteristics;
10. Radioactivity of water and bottom deposits;
11. Perfection of research methods.

Almost all of these problems required that the work of the 33rd voyage should extend and broaden the research first carried out during the 31st voyage of "VITYAZ" in the Indian Ocean.

Also, this expedition had to conduct meteorologic, radiation, and astronomic studies as well as a few other types of research.

130 persons participated in this expedition, 65 in the scientific party and 65 crew members. The following scientific divisions worked during this expedition: (1) meteorology (with L. P. Shkotkin as head); (2) hydrology (IU.A. Ivanov, head); (3) chemistry (V.N. Ivanenkov, head); (4) geology (E.I. Gordeev, head); (5) seismo-acoustic (IU.P. Neprochnov, head); plankton (L.I. Ponomarev, head); (7) benthos (F.A. Pasternak, head); (8) icthyology (N.V. Parin, head); (9) physics (IU. I. Prodan, head); (10) radioactivity studies (A.G. Zelenkov, head); (11) hydrographic group (L.P. Nasyr, head). The leader of the expedition was P. L. Bezrukov, and his substitute was I. A. Stoianov; the captain of "VITYAZ" was I. V. Sergeev.

Most of the members of the expedition came from the Institute of Oceanology, but in addition personnel from the Naval (Marine?) Hydrophysical Institute, Governmental Astronomic Institute (named Shternberg), Maritime Administration of Hydrometric Service, and several other institutions participated in this expedition.

"VITYAZ" left Odessa for the 33rd voyage October 6, 1960 and, after sailing for 31,250 miles, arrived at Vladivostok April 19, 1961. Therefore the cruise lasted 194 days. The itinerary of the expedition is shown on

Figure 1. During this voyage "VITYAZ" called at Aden, Bombay, Colombo, Calcutta and Singapore for supplies. Besides, the ship visited Diego-Garcia Atoll in the Chagos Archipelago, where the members of the expedition collected faunal samples from the littoral coral reefs. Below are a few indications of work completed:

Total number of oceanographic stations	282
Hydrographic stations	195
of these, stations deeper than 2000 m	128
Buoy, mostly 24 hours, stations	21
Stations with vertical sounding t° (BT's? - RLF)	231
Cores	104
of these, by heavy piston coring	14
Bottom photography, stations	30
Collection of suspended matter by separation, number of filters	3300
Collection of suspended matter by separation, miles	18000
Echo-sounding, miles	28645
Seismic stations, with arc-er (?) (reflection)	144
Seismic profiles with radio-buoys (refraction)	3
Collection of water 200 l.	50
Plankton collection to 500 m, stations	188
Plankton collection (deep), stations	7
Deepwater (mid water?) trawl, stations	23
Catch by ring trawls, stations	23
Edging of sound-scattering layers	36
Bottom scoops, stations (grabs)	188
Otter-trawl	4
Icthyologic catch, stations	188
Catch by a large conical net	8

During the 33rd voyage certain new instruments and methods of research which were not in use during the previous oceanic voyages of "VITYAZ", or generally in the ocean, were adopted. Some of these: gradient observations of temperature and humidity of the air with electro-psychrometer; gradient observations of temperature and wind with meteo-buoy (transliteration?); instrumental measuring of currents with BPV at depths of up to 5000 m; collection of suspended matter by separation method (was used earlier in the Antarctic expedition aboard the research vessel "OB"); work by seismic buoys (was conducted earlier in the Black Sea); work with a long (1700 m) arc-er (?) to define the average speeds of sound in sediments: a heavy coring tube of large diameter (170 mm) about 12 m long (was used in the Black Sea); observations of the artificial satellites of Earth with the aid of gyro-stabilizing platform; and several other instruments and methods of work.

In a short article it is impossible to give an account of all the scientific results of the research conducted during this expedition. Therefore we shall discuss here only a few of the basic results of the voyage, drawing on data of different scientific divisions.

One of the most important results of the voyage was the completion of sufficiently detailed oceanographic observations of such large, and at the same time little-known, regions of the Indian Ocean as the Arabian Sea, Bay of Bengal and Andaman Sea. Such complex research has never been undertaken here before. Studies within the equatorial zone of the ocean and two meridional sections in the central part of the ocean produced much new and interesting information. Research conducted in the region of the western part of the Java Trench substantially supplemented material gathered during the 31st voyage in the eastern part of the trench, and provided an opportunity to acquire a more complete picture of the structure of this deepest depression of the Indian Ocean.

It will be practical to commence with discussion of the scientific results of the geologic program, inasmuch as the bottom relief and oceanic depths define the character of the many processes taking place in the ocean.

As a result of continuous echo-sounding many of the important traits of the Indian Ocean were clearly expressed and accurately defined.

In the Arabian Sea ample material was gathered to demonstrate that beyond the boundaries of the continental slope the sea floor basically represents a vast accumulative plain. In the northern part of the sea the little-studied submarine Murray Ridge was traversed three times. Murray Ridge was discovered by the Anglo-Egyptian expedition "MABAHISS" (7). The ridge stretches from northeast to southwest and is a continuation of one of the mountainous structures on the right bank of the Indus River. Flat-topped mountains with minimum depth of 455 m were discovered on the surface of this ridge. A trench was defined, with steep slopes, flat bottom, and with a depth of up to 4230 m, adjacent to the ridge.

<u>Figure 1</u> - Track of the 33rd voyage of the research vessel "VITYAZ"

The contours and surface character of the largest submarine ridges crossing the ocean—Arabian-Indian (Carlsberg - RLF) and Mid-Indian—were defined accurately. Both ridges proved to be considerably wider than indicated on the maps. They have an exceptionally complicated and dissected relief, crowned by numerous mountains; some of these are 2 - 2.5 km high and were discovered for the first time. Along the axial part of the Arabian-Indian (Carlsberg) as well as Mid-Indian ridges a deep longitudinal valley was traced on several crossings; this corresponded to the (rift) valley described by Heezen in the more southern part of the Mid-Indian Ocean Ridge. Directly east of the Mid-Indian Ridge, in the region of the Chagos Archipelago, two crossings were made of a deep trench which had steep slopes and flat bottom, with a depth of approximately 5400 m. From its structure and position relative to the neighboring insular chain, the newly-discovered Chagos Trench is similar to other oceanic trenches. Further research is necessary to define its extent.

A large submarine mountain discovered during the 31st voyage of "VITYAZ" was subjected to detailed examination. It is situated atop the submarine ridge 550 miles south southeast of Ceylon. The ridge is in the sedimentary plain extending from the Bay of Bengal approximately to 7° South Latitude in the northern part of the Indian-Australian Basin. The shoalest part of this mountain is 1550 m deep. The name of the first Russian traveller sailing the Indian Ocean in the XVth century, Afanasi Nikitin, is given to this mountain (1).

South of 7° South Latitude, the floor of the Indian-Australian Basin is very complexly dissected, with volcanic forms of relief predominating.

Numerous submarine valleys (channels), evidently formed as a result of turbidity current activity, are encountered on the continental slope in the Bay of Bengal, and in the region of the sedimentary plain occupying the greater part of the gulf bottom. The existence here of such valleys was noted earlier by Dietz (6). In the southeastern part of the gulf the little-studied submarine ridge, with shoal depths over it from 2000 to 2500 meters, was crossed and traced.

Figure 2 - Sounding profile of oceanic floor along 83° East Longitude (from Station 4896 to Station 4912)

In the Andaman Sea, a deep trench stretching along the base of the eastern slope of the Andaman-Nicobar insular chain, as well as a submarine ridge situated east of this trench, was crossed several times. The Invisible Bank is situated atop of this ridge.

Investigations in the region of the western part of the Java Trench opposite Sumatra showed that the slopes here have a very complicated structure. Seaward of the trench a comparatively gentle swell alternates with a chain of large elevations with the characteristics of a mountain ridge, crowned by numerous peaks with shoal depths ranging from 2500 to 3000 meters.

A submarine ridge connecting the elevations of Christmas and Cocos Islands was defined. Southwest of Christmas Island a seamount more than 3 kilometers high, with a minimum depth of 1440 meters, was discovered and subjected to special study.

Some of the new data on bottom relief of the Indian Ocean collected on this voyage can be regarded as significant geographical discoveries.

Ample data regarding the composition and distribution of bottom sediments was collected. It was established that sediments are distributed extremely irregularly not only in the region of large oceanic ridges with complexly dissected surfaces (Arabian-Indian (Carlsberg), Mid-Indian, and others), but also in the deep basins remote from land (Indian-Australian, Central Indian), which have an uneven, predominantly volcanic bottom relief. The frequent and sharp contrasts of relief, with depth ranges of several kilometers in the region of ridges and usually many tens and hundreds of meters within the hilly plains (Figure 2), and the slow sedimentation rates are responsible for the extremely wide occurrence here of hard rocks, i.e. an interrupted sediment accumulation. The presence here of exposed rock is confirmed in many cases by obtaining samples of rocks (predominantly basalt) by dredging and coring, as well as by submarine photography (Figure 3). The analysis of echo-sounding profiles is not the only method producing a clear picture of this phenomenon on an extremely large scale. Without exaggeration, one may say that a numberless quantity of exposures of volcanic rocks are present on the ocean floor.

<u>Figure 3</u> - Volcanic rock exposures on the surface of the Arabian-Indian Ridge (Carlsberg) (Station 4845; depth 2600 meters)

At the same time, the abrupt depth changes in the regions of oceanic ridges and hilly deep basins govern the obvious vertical zonation in sediment accumulation. Zonation is expressed in repeated changes, often in very short distances, in the size and material composition of abyssal sediments.

The changes in grain-size of sediments from elevations to depressions in the bottom are related to changes in hydrodynamic conditions which clearly occur even at depths of more than 5 kilometers. Submarine bottom photographs show the presence of typical ripple marks, formed by powerful currents, on the surface of submarine ridges at depths up to 3 kilometers (Figure 4). Changes in the material composition of the abyssal sediments take place especially sharply in the depth interval from 4200 to 4700-5000 meters, where the pure carbonate sediments (foraminifera ooze) are replaced by carbonate-free sediments (red clays), due to the solution of calcium carbonate in the cold, deep waters.

A combination of interrupted deposition and vertical zonation of sediments in the central parts of the ocean, atop ridges and in deep basins leads to an extreme irregular and non-uniform character of abyssal sedimentation. As the regions of irregular relief occupy at least 3/4 of the ocean floor, it becomes clear that sporadic sediment accumulation represents one of the most characteristic traits of oceanic sedimentation, a fact which till now has not been sufficiently noted.

A different picture is observed in the region of accumulative abyssal plains, usually situated in the marginal parts of the ocean--for example, the floor of the Arabian Basin and Bay of Bengal with the adjoining northern part of the Indian-Australian Basin. Here, the contemporary sediments are distributed more evenly and changes in their composition take place gradually. At the same time, below the recent surface of the abyssal plains sediments deposited by turbidity currents are widely distributed. Such sediments include the interlayers of compact usually micaceous, sands and silt encountered in many long cores taken at depths as great as 5000 meters.

The distribution of various types of bottom sediments was determined; wide occurrence of manganese-iron nodules in the Indian-Australian Basin was established; and new data was gathered on the distribution of radiolarian and ethmodiscus oozes, which were encountered for the first time in the reduced as well as in the oxidized zones of sediments. The presence of hydrogen sulfide nearly everywhere in the sediments along the continental slope and at its base was established; a map of thicknesses of the upper oxydized layer of sediments in the northern part of the ocean was constructed. Descriptions were made of the content of free iron and iron oxide, manganese++++, and sulfide sulfur.

Figure 4 – Ripple marks formed by currents on the crest of the Arabian-Indian Ridge (Carlsberg) (Station 4823; depth 2000 meters)

The seismo-acoustic group conducted extensive work to determine the thickness of sediments by reflection methods, using the piezoseismographic arc-er (?). In the vicinity of the Arabian Sea abyssal plain the thickness of sediments gradually decreases from north to south, from 2.5 to 0.5 kilometers (3). In the Bay of Bengal the thickness reaches a maximum of 3 kilometers; in the adjacent part of the Indian-Australian Basin the thickness reaches 2.5 kilometers; in the central part of the ocean, the thickness ranges from 400 to 100 meters. On the numerous volcanic mountains, as indicated above, the thickness of sediments is zero. In the Java Trench the thickness of unconsolidated sediments is 2 - 3 kilometers.

Three seismic refraction profiles were shot, using automatic seismo-acoustic buoys. It was established that in the Indian-Australian Basin basalts underlie the sediments. Here the thickness of the earth's crust was found to be equal to 7.0 ± 1.5 kilometers (4).

The meteorologists carried out various hydrometeorological, atmospheric, and radiant energy observations during the voyage, constructed synoptical charts and provided the expedition with weather forecasts. In addition, this group carried out lapse rate observations of temperature and humidity of the air aboard the ship with the aid of electropsychrometers. On several stations gradient observations of the wind and temperature in the atmospheric layer next to the water were conducted with the aid of a meteobuoy.

The hydrographers constructed charts and profiles t^o of temperature and salinity for the northern part of the Indian Ocean. Problems of the formation of temperature fields and salinity were studied. According to data of IU.A. Ivanov, temperature distribution is determined by positive heat exchange at the surface of the ocean and by negative, predominantly turbulent, exchange at oceanic depths. As a result of the interplay of these processes the observed distribution of temperature is established: at the surface the water temperature fluctuates between the limits of 26 - 28°, next to bottom within 1.3 to 1.7°. In the upper layer, the water is warmer in the Bay of Bengal than in the Arabian Sea; within the layer from 150 meters to the bottom a reversed picture is observed. This is explained by the fact that as a result of sedimentation being greater than evaporation in the Bay of Bengal (as compared with the Arabian Sea), a sharply defined layer of rapidly increasing (with depth) density, preventing vertical mixing of the waters, is formed. Distribution of temperature in the Andaman Sea is determined by an intensive vertical mixing which leads to an increase of heat beneath the surface layers. Below 1500 meters, the water temperature is about 5°, i.e. it equals the temperature at the threshold of the deepest strait.

The salinity field in the northern part of the Indian Ocean is determined by the interaction of the sources of salinity (Red Sea, Aden, Persian and Oman Gulfs, the northern part of the Arabian Sea, and the central part of the ocean) and the sources of dilution (Bay of Bengal, Andaman Sea, the northeastern part of the ocean, and the Antarctic water).

In the Arabian Sea three layers of high-salinity water are found: the sub-surface layer of the Arabian Sea proper; the intermediate layer formed in the Persian Gulf; and the lower layer of the Red Sea origin. Further away from their sources, these layers are mixed and lose their individuality. Penetrating into the eastern part of the ocean, they are finally mixed together and fill the Bay of Bengal as one layer of increased salinity. Decreased salinity is observed in the surface layer of the northeastern and eastern parts of the ocean and in the deep layers just above the bottom in the whole of the northern part of the Indian Ocean.

In the Arabian Sea, Bay of Bengal, and two meridional sections in the central part of the ocean, the areas of rising and descending waters are bounded by the isolines of temperature. In the central part of the ocean, where all the processes have a well defined zonal character, the frontal zones are very noticeable; equatorial convergence (2 - 3° South Latitude), southern equatorial divergence (8° South Latitude), tropical convergence (20° South Latitude), subtropical divergence (29 - 32° South Latitude).

Analysis of data from the instrumental measurements of currents (automatic buoy stations, compared with parallel observations aboard ship) and the charts of dynamic topography show that in November and the first ten days of December, 1960 the system of currents as a whole did not correspond to the winter monsoon, in spite of the fact that the predominating winds were northwestern. In the Bay of Bengal (February to beginning of March, 1961) the currents corresponded to the charted characteristics for the winter monsoon. The instrumental observations of the currents on the buoy stations qualitatively agree well with the charts of dynamic topography constructed during the voyage.

Instrumental measurements of currents conducted at great depths (up to 5000 meters) show the presence of considerable speeds through the whole water column.

Five buoy stations on the equator were occupied. On one of these (4948) a powerful sub-surface current was discovered; this apparently is analogous to the Cromwell Current in the Pacific Ocean.

The chemistry group collected abundant material on the chemical structure of oceanic waters. At all the hydrographic stations identification was made of O_2, pH, alkalinity, phosphate, nitrite, nitrate, and silicate, as well as of ammonia, hydrogen sulfide, and total phosphorus on some stations. In addition, studies were conducted of pH, Eh, water content, and the density of bottom sediments, also of the chemical composition of included waters.

In places in the northeastern part of the Arabian Sea, within the oxygen minimum layer, a total absence of oxygen at a depth of 250 meters from the bottom (832 meters) was discovered. Oxygen deficiency is observed here not only at all depths, but also on the surface. Values of pH, having the same character of distribution as O_2, reach their minimum in the Arabian Sea (7.64 - 7.67).

The distribution of nitrites was studied in detail. The second highest content of nitrites, discovered for the first time during the 31st voyage, was traced over the vast surface of the Arabian Sea. The maximum quantity of nitrite nitrogen here equals 75 mg/m^3, which is the highest for the whole of the World Ocean. The second highest nitrite content spreads south and south-east, approximately to 90° East Longitude (in a layer of from 150 - 300 to 400 - 800 meters).

In the Arabian Sea, hydrogen sulfide in quantities of 0.02 - 0.10 ml/liter was discovered in the layer of minimum oxygen concentration and the second highest nitrite content (from 150 - 250 to 600 - 1000 meters). Earlier, it had been noted by the "MABAHISS" expedition in the near-bottom layer near the entrance to the Gulf of Oman by Ras-El-Khadd Cape, and also near Bombay. It was established that hydrogen sulfide is widely distributed in the northern part of the Arabian Sea. Hydrogen sulfide was also discovered in the north-western part of the Bay of Bengal, in the same layer (0.02 - 0.06 ml/l) (2). The discovery of hydrogen sulfide over vast areas of the intermediate waters of the Arabian Sea throws additional light on the cause of the episodic death of fish in this sea.

A study in the central part of the ocean showed that well-expressed zoning appears in the distribution of all the observed chemical components. This zoning reflects the changes of such dynamic factors as mixing, currents, and zones of rising and descending waters. The frontal zones recognizable by their physical characteristics (temperature, salinity) are expressed just as clearly with respect to their chemical elements.

Great efforts were made to determine the primary production of phyto-plankton. According to IU.G. Kabanova, during the voyage primary production proved to be low. The highest volume was found in the Andaman Sea (where a higher nitrate content was observed in the surface waters) and in the region of the Somalian current. Here, the primary production reached 300 mg C/m^2 a day. In the central part of the ocean a negligible quantity of phytoplankton in the tows attested to the low volume of the primary production.

The planktonologists conducted research on the composition and quantitative distribution of phyto-and zoo plankton, and constructed the relative charts.

The greatest quantity of phytoplankton was encountered in the Andaman Sea where, in the north, the "blooming" of blue-green algae was observed. In conjunction with the flowering of phytoplankton here as well as in the Gulf of Aden, an extremely low phosphate content (with a slightly increased nitrate content) in the surface water was noted. In the Arabian Sea the quantity of phytoplankton was less, with alternating zones of increased and decreased quantities. South of the Arabian Sea, in the zone of the south-equatorial divergence, an increased quantity of phytoplankton was noted. The Bay of Bengal proved to be low in phytoplankton; however, directly south of it a maximum burst of diatoms was observed in the zone of the northern monsoon current. In the central part of the ocean there is very little phytoplankton; peridinium predominate here.

The greatest zooplankton biomass was observed in the layer 0 - 100 meters in the Arabian Sea, similarly to the previous voyage. This sea is outstanding in the quantity of tropical zooplankton. In the Bay of Bengal the biomass is considerably smaller, and in the Andaman Sea it is slightly larger than in the Bay of Bengal. In the open ocean, some increase in the zooplankton biomass was noted in the zone of south-equatorial divergence; an extremely low quantity was noted in the anticyclonic zone southward to 38° South Latitude; than, still further south, an increase in biomass was once more observed.

The 200 - 500 meter layer is distinguished everywhere by the low quantity of zooplankton; this is especially noticeable in the zone of hydrogen sulfide contaminated waters in the Arabian Sea.

Investigations of the deep scattering layers were carried out. Collections showed that these layers are formed primarily by bathypelagic fish (predominantly myctophids), decapods, euphausids, and salps.

The Benthos Division, employing the ample collection of bottom fauna, succeeded in constructing a detailed picture of the distribution of total biomass, as well as of the biomass of separate groups of benthos. The central part of the Arabian Sea is characterized by comparatively high biomass (of the order of 0.5 - 1.5 g/m^2). In the northern part of the sea, the biomass is sharply decreased as a result of contamination of the intermediate waters by hydrogen sulfide; at the same time a sharp qualitative deterioration in the fauna is noted. On several peaks of the Murray Ridge, washed by the contaminated waters, there was a total absence of bottom fauna. In the Bay of Bental the benthic biomass is lower on the average than in the Arabian Sea. This biomass is gradually decreasing from the coastal shallow waters towards the central regions. Throughout the whole area under investigation, first place in the total biomass is occupied by polychaetes; the second place belongs to the crustacea, the average quantity of which in the Arabian

Sea is considerably lower.

Of great scientific interest is the discovery, on several stations in the tropical zone of the ocean, of deepwater crustacea of the mysids family, considered earlier to be distributed bipolarly. The collections of this group have a few new types.

The icthyologists studied the pelagic and deepwater ichthyo-fauna, and conducted research on the reproduction and development of fish, collecting the coastal fish as well as pelagic specimens.

Of the greatest practical interest was the discovery of a region, at the mouth of the Gulf of Aden and in the zone of the Somalian current, rich in pelagic predatory fish (tunny and coryphaena). Here large quantities of coryphaenas (dolphin?) were encountered. At some stations the catch reached 50 - 100 fish per hour of fishing. Sizable shoals of small tunny (striped and yellow-scaled), limited to the surface waters, also were encountered. Evidently this region should be considered promising for the development of oceanic trade.

During this voyage, a large collection of pelagic fish, representative of the composition of ichthyo-fauna in the observed region, was gathered. The flying fish is especially well represented: some types were noted for the first time in the Indian Ocean.

Much material was also gathered regarding abyssal fish. There are many new, rare, and little-studied types, and several forms unknown previously for the Indian Ocean. New data defines with considerable accuracy the general understanding of distribution of the abyssal fish in the Indian Ocean.

Undoubtedly, the material covering the distribution of the young of the tunny, flying fish, and various groups of abyssal fish is of great interest. N. N. Gorbunova discovered an exceptionally large accumulation of tunny larvae in the Aden Gulf and in the waters of the Somalian Current.

The physicists, using the gyrostabilizing platform, conducted observations of the artificial satellites and photographed regions of the Milky Way which cannot be seen from Soviet observatories. Such work was conducted for the first time on oceanographic expeditions. In addition, the division conducted radio-physical observations. The Division of Radioactive Studies completed extensive work on the radioactivity of water (to maximum depths), as well as of water-suspended matter.

To sum up, one may conclude that the 33rd expeditional voyage of "VITYAZ", as well as its 31st voyage, considerably broadened our concept of the nature of the Indian Ocean. It is essential to study further the vast amount of material gathered by the expedition, and to expedite all the work involved.

In conclusion, it should be stressed that during the whole voyage, lasting six and a half months, under trying tropical conditions, a spirit of mutual help prevailed between the scientific staff of the expedition and the ship's crew. This not only facilitated completion of the program of research, but enabled us to accomplish much more work than proposed, and in a shorter time.

P. L. BEZRUKOV

Literature

1. Bezrukov, P. L., Zatonski, L. K., and Sergeev, I. V., 1961, The Afanasi Nikitin Mountain in the Indian Ocean, Dokl, Acad. Sci. USSR, 139, No. 1;

2. Ivanenkov, V. N., and Rozanov, A. G., 1961, Hydrogen sulfide contamination of the intermediate layer of waters in the Arabian Sea and Bengal Gulf, Oceanology, No. 3;

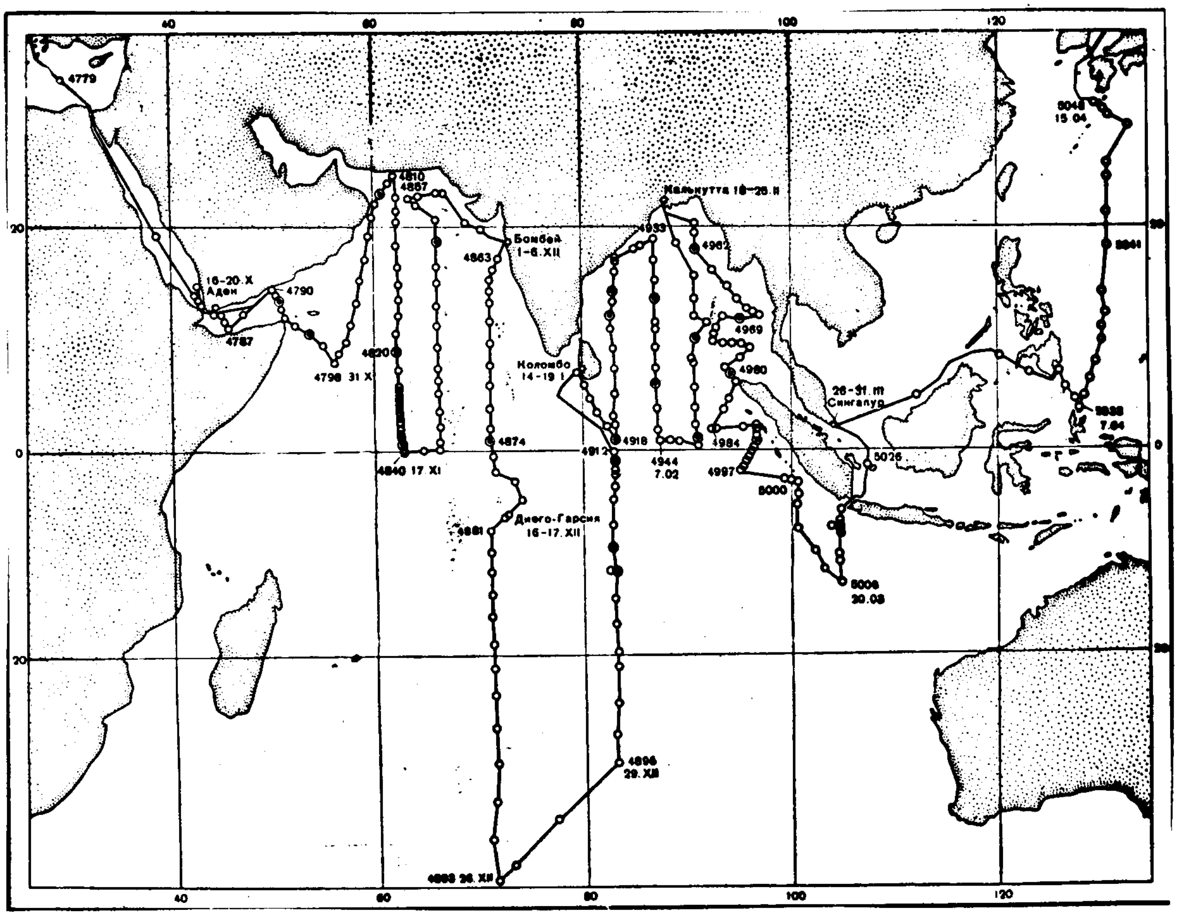
3. Neprochnov, IU. P., 1961, Sediment thickness of the Arabian Sea Basin, Dokl, Acad. Sci. uSSR, 139, No. 1;

4. Neprochnov, IU. P., 1961, New data on the structure of the Earth's crust in the Indian Ocean, Dokl, Acad. Sci. USSR (in print);

5. Oceanologic research, 1961, Collec. articles, 10th division of program MGG (Oceanology), No. 4;

6. Dietz, R., 1954, Possible deep-sea turbidity current channels in the Indian Ocean, Bull. Geol. Soc. Amer., 64, No. 12;

7. Wiseman, J. D. H., and Sewell, R. B. S., 1937, The floor of the Arabian Sea, Geol. Mag., 74.



<u>Figure 1</u> - Track of the 33rd voyage of the research vessel "VITYAZ"

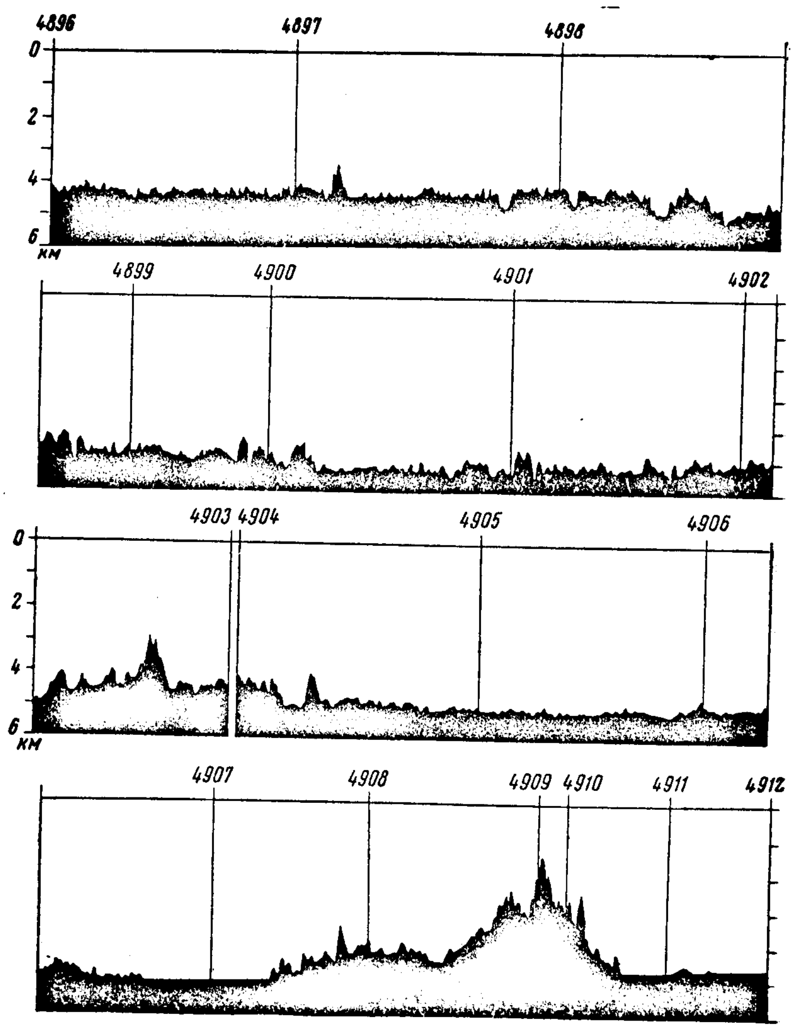


Figure 2 - Sounding profile of oceanic floor along 83° East Longitude (from Station 4896 to Station 4912)

Figure 3 - Volcanic rock exposures on the surface of the Arabian-Indian Ridge (Carlsberg) (Station 4845; depth 2600 meters)

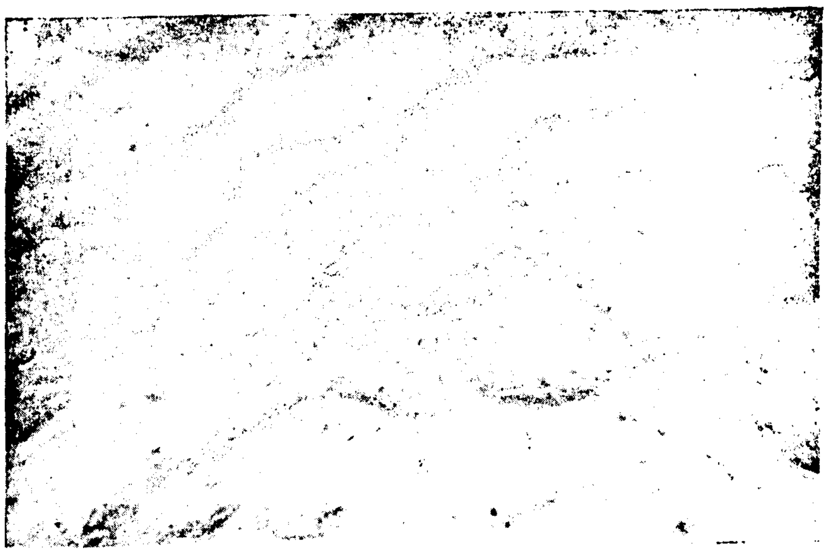


Figure 4 - Ripple marks formed by currents on the crest of the Arabian-Indian Ridge (Carlsberg) (Station 4823; depth 2000 meters)